SOIL MECHANICS TERMS

Source: http://environment.uwe.ac.uk/geocal/GLOSSARY/GLOSS_A.HTM

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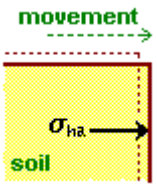
II. TERMS

acceleration due to gravity (g)

g = 9.81 m/s² at sea level.

active earth pressure (s_{ha} , s'_{ha})

The minimum horizontal stress exerted by a mass of soil on a retaining surface as the surface moves **away** from the soil, e.g. the pressure exerted behind an earth-retaining wall.



activity (A)

$$A = \frac{I_p}{\%\ \text{clay fraction}}$$

Typical values:
Kaolin clay 0.4-0.5
Illite clays 0.75-1.25
London clay 0.95
Montmorillonite clays >2.0

adhesion

The shear resistance between soil and another material (e.g. steel, concrete or timber; along a pile shaft or beneath a retaining wall). In physics, adhesion is described as 'the force that holds together molecules or **unlike** particles within a substance'. (See also cohesion)

adsorbed water

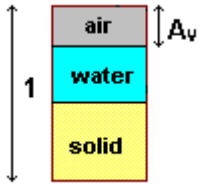
Water held on the surface of flaky particles (e.g. clay) by electrostatic charge. The ions forming the platy surfaces of clay carry a negative charge and thus attract the positive end of bipolar water molecules.

ageing

Processes that occur with time, independent of changes in loading, and cause changes to the state of a soil, e.g. vibration, compaction, creep, cementing, weathering, changes in salinity.

air-voids content (A_v)

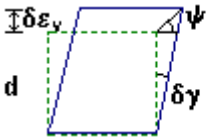
(Also **air-void ratio** or **air content**) The ratio of the volume of air to the total volume of a body of soil.



allowable bearing capacity (q_a)

The bearing pressure that can be allowed on a foundation soil, usually to limit settlements. Units: kPa

angle of dilation (y)



$$\tan\psi = \frac{\delta\varepsilon_v}{\delta\gamma}$$

Defined by the ratio between the rate of volumetric strain and the rate of shear strain (note: the value is positive for dilation); also the direction of relative motion across a slip plane.

angle of friction (f')

The general Mohr-Coulomb failure criterion is given by:
t' = c' + s' tan f'
where f' is the angle of friction. Because soil can have different definitions of failure, it is necessary to identify the particular state described:
f'_p refers to the peak state
f'_c refers to the critical state
f'_r refers to the residual state

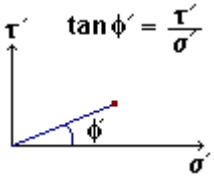
angle of ground slope (b, i)

The angle referred to horizontal of the ground surface.

angle of repose

The maximum angle of a just-stable slope of a heap of dry granular material.

angle of shearing resistance (f'_{mob})



Defined by the ratio of effective shear and normal stresses mobilised at any state (e.g. prior to failure).
Also, f'_{max} is the angle of shearing resistance at the peak state.
$t'_p = s' \tan f'_{max}$
$f'_{max} = f'_c + y$
where y is the angle of dilation.

angle of slip plane

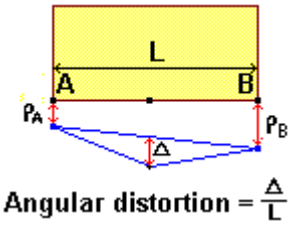
The angle referred to horizontal of a plane or other surface along which a discontinuous slip or rupture will occur, e.g. behind or in front of a retaining wall.

angle of wall friction (d)

The angle of friction between soil and the surface of a structure (e.g. retaining wall, underside of foundation). The maximum resistance to sliding along the surface is N.tand, where N is the force normal to the surface.

angular distortion (D/L)

The ratio between the relative deflection (D) between two points in a foundation and the distance between them (L).



anisotropic

Not the same in all directions. In soils, properties in a horizontal direction may be different to those in a vertical direction, for example.

aquifer

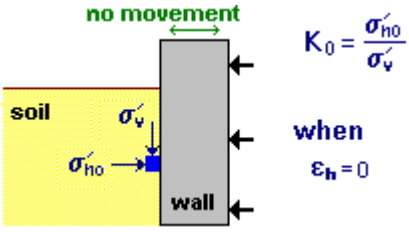
A stratum of relatively high permeability; a water-bearing stratum of rock or soil.

artesian

Artesian conditions exist when the water table (piezometric surface) lies above ground level.

at-rest earth pressure (s_{ho}, s'_{ho})

The horizontal stress developed in a mass of soil loaded in conditions of zero horizontal strain.



axial strain (e_a)

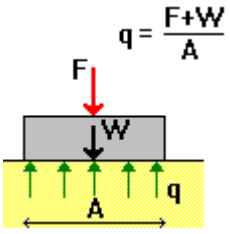
Direct strain measured along an axis, e.g. along the axis of a triaxial test sample.

axial stress (s_a, s'_a)

Total or effective stress acting along an axis, e.g. along the axis of a triaxial test sample.

bearing pressure (q)

The total stress transferred from the underside of a foundation to the soil below. Units: kPa



bedrock

Rock underlying surface deposits of soil and weathered or broken rock; usually material which is so stiff and strong that it is easily able to carry foundation loads.

boulders

Soil grains over 200mm in size.

British Soil Classification System

A system of classification based on size, consistency and structure, set out in BS 5930:1981 *Site Investigation*.

bulk density (r)

The total mass of soil particles and water contained in a unit volume of soil. Units: Mg/mł

$r = (M_s + M_w) / V$

where

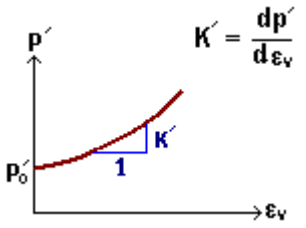
M_s = mass of soil grains

M_w = mass of water

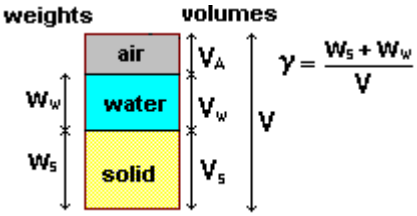
V = total volume.

bulk modulus (K')

The ratio of a change in applied mean normal effective stress to the resulting change in volumetric strain. Units: kPa



bulk unit weight (g)



capillary rise (h_c)

The height to which water will rise above the water table due to capillarity.

clay

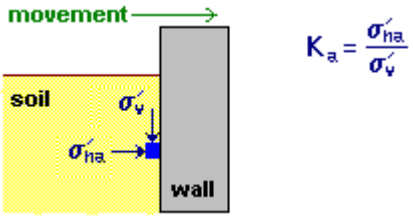
Soil particles less than 0.002mm in size.

coarse-grained soils

Soils with less than 35% by mass of grains less than 0.06mm in size.
Coarse soil: grain size is predominantly 0.06-60mm
Very coarse soil: grain size is predominantly greater than 60mm

coefficient of active earth pressure (K_a)

The ratio of the minimum horizontal effective stress to the vertical effective stress at a point in a soil mass retained by a surface as the surface moves away from the soil.



coefficient of consolidation (c_v and c_h)

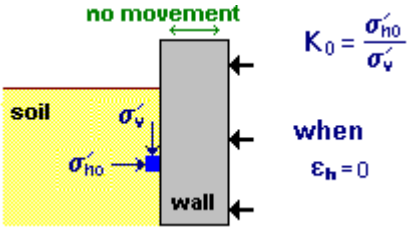
$$c_v \frac{\partial^2 \bar{u}}{\partial z^2} = \frac{\partial \bar{u}}{\partial t}$$

A measure of the rate of change of volume during primary consolidation; referred to either vertical drainage (c_v) or horizontal drainage (c_h). Units: m^2/s

coefficient of curvature of grading (C_z)

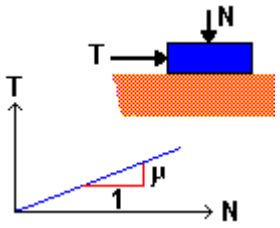
(Also curvature coefficient) A measure of the shape of a grading curve:
$C_z = d_{30}^2 / (d_{60} \times d_{10})$.
See particle size characteristics

coefficient of earth pressure at rest (K_o)



The ratio of horizontal effective stress to vertical effective stress at a point in a soil mass loaded in conditions of zero horizontal strain.

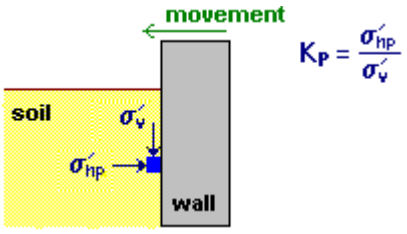
coefficient of friction (m)



The ratio between the tangential force (T) required to cause a body to slide along a plane and the normal force (N) between the body and the plane:
$T = mN$.

Along a wall or foundation surface:
$m = \tan d$
where d = angle of wall friction

coefficient of passive earth pressure (K_p)

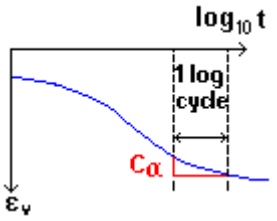


The ratio of the maximum horizontal effective stress to the vertical effective stress at a point in a soil mass retained by a surface as the surface moves toward from the soil.

coefficient of permeability (k)

The constant average discharge velocity (v) of water passing through soil when the hydraulic gradient (i) is 1.0; defined by Darcy's law:
$v = k.i$

coefficient of secondary consolidation (C_a)

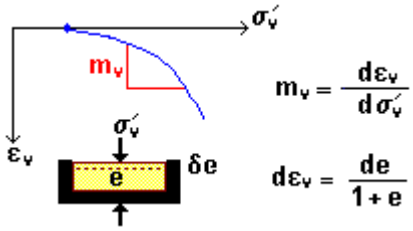


The change in volumetric strain per $\log_{10}$ cycle of time after primary consolidation is complete.

coefficient of uniformity of grading (C_u)

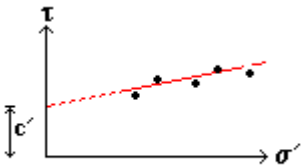
(Also uniformity coefficient) A measure of the slope of a grading curve and therefore the uniformity of the soil in particle size analyses: $C_u = d_{60} / d_{10}$
See particle size characteristics

coefficient of volume compressibility (m_v)



The change in volumetric strain per unit volume per unit change in effective stress in one-dimensional compression. (Units m^2/MN)
Compressibility is the reciprocal of stiffness.

cohesion (c')



Apparent cohesion (c′) is the intercept on the shear stress axis of a straight-line Mohr-Coulomb envelope. For critical states and residual states, $c'_c = c'_r = 0$ in most cases. For peak states, a curved strength envelope also passes through the origin, but a straight-line fitted to a small number of results is often extrapolated to give an intercept $c'_p > 0$. (In physics, cohesion is described as 'the force that holds together molecules or like particles within a substance'.)
See also adhesion and true cohesion.

compaction

Volume change in soil in which air is expelled, but with the water content remaining constant. Compaction may occur due to vibration in loose sands and gravels, and in fill due to self-weight. In soil constructions, compaction is achieved by rolling, tamping or vibrating.

compatibility

The relationship between the strains in a deforming body so that no holes appear and no material is destroyed.

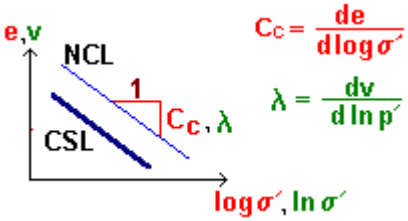
compressibility of pore fluid (C_v)

$$C_v = \frac{d\varepsilon_v}{d\sigma}$$

The ratio of the change in volumetric strain to the change in isotropic stress. For a saturated soil, C_v = ¥

compression index (C_c)

The slope of the normal compression line (NCL) and critical state line (CSL).



cone resistance (q_c)

The resistance force divided by the end area of the cone tip, measured during the cone penetration test.

cone penetration test

A penetration test in which a sleeved cone (diameter 35.7mm, end area 1000mm², apex angle 60º) is pushed into the ground at a rate of 20 mm/min and the force required measured. The magnitude of this force divided by the end area is called the *cone penetration resistance* (q_c). The cone and the sleeve can be advanced separately and so the frictional resistance along the sleeve (1000mm² area) or *local side friction* (f_s) can also be measured.

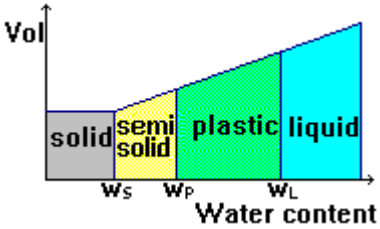
confined aquifer

A *confined* aquifer is contained between two strata of low permeability; in flow analyses, a confined aquifer is often assumed to be saturated throughout its depth.

consistency index (I_c)

A measure of the relationship between the current water content and the consistency limits, similar in form to the density index, but expressed in terms of water content.
$I_c = (w_L - w)/I_P$
At liquid limit, $I_c = 0$
At plastic limit, $I_c = 1.0$

consistency limits



(Also called Atterberg limits) Measures of water content corresponding to changes in physical state of a soil:
liquid limit (w_L) = w/c at the change from liquid to plastic
plastic limit (w_P) = w/c at the change from plastic to semi-solid
shrinkage limit (w_s) = w/c below which no further shrinkage upon drying occurs

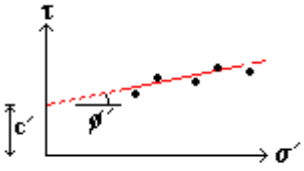
consolidation

Volume change due to dissipation of excess pore pressure, usually with constant total stress.

consolidation settlement (s_c, r_c)

The settlement of a foundation due to consolidation.

Coulomb's equation



(After Charles Augustin Coulomb, 1736-1806) An equation relating the shear strength of soil to the normal effective stress on a failure plane.

$t_f = c' + s' \tan f'$
$= c' + (s - u) \tan f'$

creep

Deformation or volume change which occurs in soil at constant effective stress progressing with time.

critical circle

In slope stability analyses the slip circle corresponding to the lowest factor of safety.

critical ground slope angle (i_c)

The ground slope angle that corresponds to a slope-stability factor of safety of 1.0.

critical height (H_c)

The height of a slope (e.g. embankment, cutting, trench) for which the factor of safety against collapse is 1.0.

critical hydraulic gradient (i_c)

The hydraulic gradient at which effective stresses becomes zero; with upward seepage, sand may become quicksand.

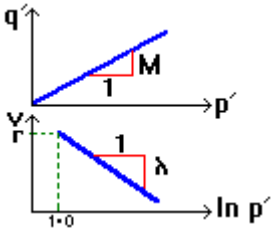
critical shear strength (t_c)

The shear stress developed along a slip surface during shearing at constant volume; also known as ultimate shear strength.

critical state

The state of a soil in which it strains; critical states occur on the critical state line.
Note: The critical state is not the same as the residual state; at the critical state, soil particles continue to rotate and the flow is turbulent; at the residual state, in clay soils, flat particles become aligned to the slip plane and the flow is laminar.

critical state line (CSL)



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The unique relationship at failure between deviator stress, average normal stress and volume (or shear stress, normal stress and void ratio) is defined by the critical state line.

$q' = Mp'$
$v = G - l \ln p'$

$t' = s'_n \tan f'$
$e = e_G - C_c \log s'_n$

critical void ratio (e_c)

The void ratio of a soil at which its volume remains constant during shearing.
Note: critical void ratio depends on the mean stress.

current state of soil

The current state of a soil is described by its voids ratio (e) or specific volume (v), the current stress (s' or p') and the overconsolidation ratio or yield stress ratio (R_y).

Darcy's law

(After H.P.G. Darcy, 1856) Concerns the laminar flow of water through porous media and states that the velocity of flow (v) in a saturated soil is equal to the product of the coefficient of permeability (k) and the hydraulic gradient (i).

$v = ki$

degree of consolidation (U_t)

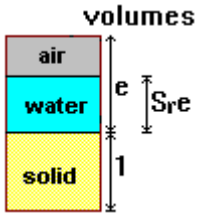
$$U_t = \frac{\bar{u}_o - \bar{u}_t}{\bar{u}_o - \bar{u}_\infty}$$

$$\text{or } U_t = \frac{\rho_t}{\rho_\infty}$$

The proportion of consolidation that has occurred after a given elapsed time; may refer to the dissipation of excess pore pressure at a point, or to the average dissipation throughout a consolidating layer.

degree of saturation (S_r)

The proportion of the void space occupied by liquid.



$$S_r = \frac{V_w}{V_v}$$

where
V_w = volume of liquid
V_v = volume of voids

density

The mass per unit volume of a substance.
Units: Mg/m^3 , kg/m^3 , g/ml.

density index (I_D)

(Also relative density D_r) A measure of the relationship between the current void ratio and the maximum and minimum void ratios; will indicate the state of compaction in sands.

$$I_D = \frac{e_{max} - e}{e_{max} - e_{min}}$$

In the loosest state, $I_D = 0$; in the densest state, $I_D = 1$

density of soil grains (r_s)

The average density of the mineral or rock of which the soil particles are composed.

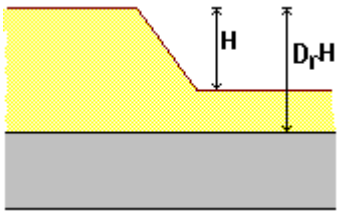
$r_s = G_s r_w$

density of water (r_w)

The density of water varies with temperature and pressure, the standard value being 1.00Mg/m^3 at 4º Celsius; this value is sufficently accurate in all soil mechanics problems.

depth factor (D_r)

The ratio between the depth of a slip circle below the top of a slope and the height of the slope; often used to specify the depth of a harder stratum below the slope which may control the depth of the critical circle.



deviator stress (q, q')

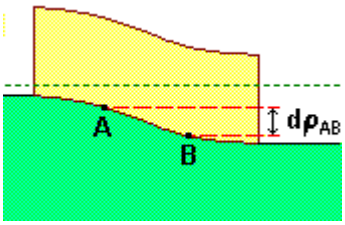
For a triaxial sample,
$q = s_a - s_r$
$q' = s'_a - s'_r$

diagenesis

Literally meaning 'double birth', describes the processes of change that turn loose sediments into solid rock; these are a combination of consolidation (the squeezing out of water) due to the increasing pressure of overlying deposits and the formation of mineral cement between grains.

differential settlement (dr)

The displacement due to settlement of one point in a foundation with respect to another point.



direct strain (e)

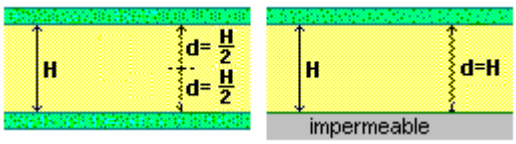
$$\varepsilon = \frac{\delta L}{L_0} \quad \left[\begin{matrix} + = \\ \text{compression} \end{matrix}\right]$$

The ratio of the change in length to the original length.

distance along flow line (s)

Distance measured in the direction of flow in a seepage system.

drainage path length (d)



The length of path followed by water flow in seepage problems. For vertical flow in horizontal layers, the maximum flow path followed to the outflow boundary i.e. d=H/2 for open layers or d=H for half-closed layers.

drained loading

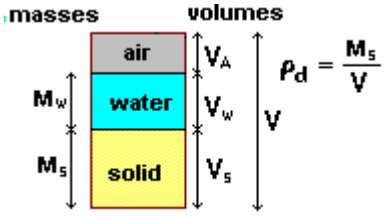
Loading which is so slow that water is able to seep (drain) from the soil as the total stresses increase; consequently, there will be no change in pore pressure and volume change will follow change in loading.

drawdown (d_w)

The magnitude of the lowering of a water surface or water table, e.g. in or adjacent to a pumping or observation well.

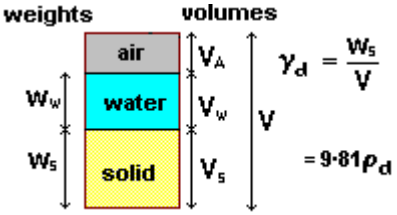
dry density (r_d)

The mass of soil grains (ignoring water) contained in a unit volume of soil. Units: Mg/m³.



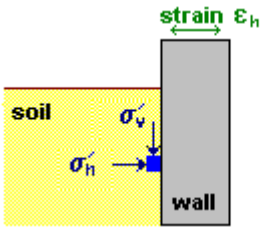
dry unit weight (g_d)

The weight of soil grains in a unit volume of soil.



Units kN/m³

earth pressure coefficients



$K = \frac{\sigma'_h}{\sigma'_v}$

The ratio of the horizontal effective stress acting on a supporting structure and the vertical effective stress in the soil at that point:

K_o = coefficient of earth pressure at-restATREST (when $e_h = 0$)
K_a = coefficient of active earth pressureACTIVE (as the structure moves away from the soil)
K_p = coefficient of passive earth pressurePASSIVE (as the structure moves toward the soil)

For a smooth wall:
$K_a = \tan^2(45° - ½f')$
$K_p = \tan^2(45° + ½f')$
See also earth pressure coefficients in undrained conditions

earth pressure coefficients for undrained conditions

These are defined in terms of total stresses as follows:
$s_h = s_v - K_{au} s_u$
(as the structure moves away from the soil)
$s_h = s_v + K_{pu} s_u$
(as the structure moves toward the soil)
For a smooth wall, $K_{au} = K_{pu} = 2$

effective stress (s')

The stress in a soil mass that is effective in causing volume changes and in mobilising the shear strength arising from friction; the principle of effective stress states that "all changes in a soil's volume, shape or shearing resistance are due exclusively to changes in effective stress".

effective stress = total stress - pore pressure

$s' = s - u$

effective stress ratio (h)

The ratio of deviator stress to mean effective normal stress
$h = q' / p'$
(similarly, $\tan f'_{mob} = t' / s'$)

efficiency of a pile in a group (x)

For a given pile in a group, the ratio of the average ultimate load in the group to the individual ultimate load on that pile; piles on the outside of a group are generally more heavily loaded than those near the centre. For driven piles in sands x may be greater than 1; for bored piles x may be as low as 0.6.

elastic deformation

Deformation caused by a change in loading that is recovered completely when the load is removed.

elevation head (h_z)

In seepage problems, the height of a point above a given datum.

equipotential

In a flow net, lines connecting points of equal total head; usually drawn so that the interval, or equipotential drop, is constant. Equipotentials intersect flow lines and impermeable boundaries at right angles.
N_d = number of equipotential drops in a flow net between the inflow and outflow boundaries.

excess pore pressure

$$u = u_o + \bar{u}$$

The amount of pore pressure greater or smaller than the long-term steady-state pore pressure (u_o); excess pore pressure is dissipated during consolidation.

factor of safety (F_s)

The ratio of a limiting value of a quantity to the design value of that quantity, e.g. the ultimate load divided by the design load. The quantity used can be a measure of force, moment, stress, displacement, size, or other design measure. The magnitude of a factor of safety deemed to be acceptable depends on the acceptable degree of risk, the probabilities associated with occurrence of limiting conditions, the quality of data, and the method of calculation.

failure envelope

The graph of the shear stress and normal effective stresses at which shear failure occurs. Because different failure states can be defined for soils, there are different failure envelopes for peak strength, critical state strength and residual strength.

fault

A shear fracture in a rock mass along which movement has taken place.

fine-grained soils

Soils containing >35% particles smaller than 0.06 mm in size.

fines

Soil grains smaller than 0.06 mm, e.g. CLAY, SILT.

finite or large increment (D)

The symbol D placed before a quantity symbol indicates a finite or large change in the quantity,
e.g. Ds = a finite change in stress.

fissured clay

A clay having an internal network of narrow joints or fissures, which tend to open upon drying and permit rapid entry of water when exposed to weathering, e.g. London clay.

fissures

Small, but often numerous, cracks, particularly in clay soils. (See also fissured clay)

flow line

(Also stream lines) The path followed by water particles in seepage flow; in a flow net, represent direction and path of flow.
N_f = number of flow lines in a flow net connecting the inflow and outflow boundaries.

flow net

A graphical representation of seepage flow in a body of soil, in which flow lines and equipotential lines intersect at right angles. Used in problems concerning groundwater seepage through embankments and earth dams, and under dams and cut-offs, to estimate flow quantities and pore pressures.

flow quantity (Q)

The total quantity of water flowing in a seepage problem (e.g. in flow net or permeability test). Units: mł, ml.

flow rate (q)

The rate of flow is the quantity flowing in unit time. Units: mł/s, litres/min.

flow velocity (v)

(Also discharge velocity) The velocity of flow through soil.
v = q / A
where q is the quantity flowing in unit time and A is the total area of water and soil grains. So v is not the same as the velocity of a drop of water within the soil.

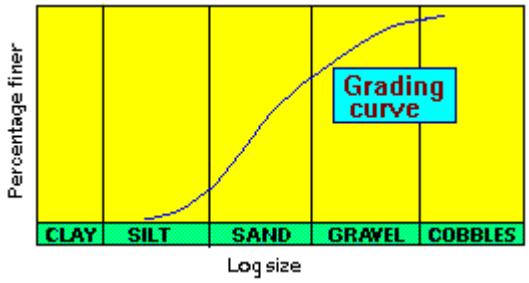
force

The action that tends to accelerate a body or to change its direction of movement. The SI unit of force is the newton (N) [after Sir Isaac Newton] and is the force required to accelerate 1.0kg by 9.81m/s¸. Weight is a force acting downward.

founding depth (D)

The depth below the ground surface of the base of a foundation.

grading curve

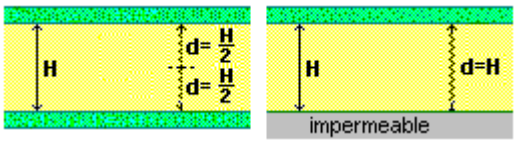


A curve drawn to represent the distribution of particle sizes in a soil. It is drawn through percentage-finer/log-size points in the interpretation of sieving and other tests.

gravity walls

Retaining and other walls which depend upon their weight to provide stability against overturning and sliding; usually made from mass concrete, brickwork or masonry.

half-closed layer



A layer or stratum or soil from which pore water may drain only upward or only downward into either an overlying or an underlying permeable layer, thus enabling 'one-way drainage'; drainage path length = layer thickness.

historical maximum stress (s'_m, p'_m)

The maximum stress to which an overconsolidated soil has be subjected in the past:
s'_m = historical maximum normal effective stress
p'_m = historical maximum mean normal effective stress
s'_{vm} = historical maximum vertical effective stress
= preconsolidation stress

horizontal strain (e_h)

Strain measured in horizontal direction.

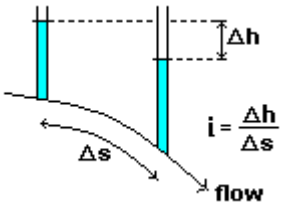
horizontal stress (s_h, s'_h)

Total or effective stress acting in a horizontal direction.

Hvorslev surface

Named after Prof. M.J.Hvorslev, that part of the state boundary surface corresponding to peak states and lying on the dry side of critical states.

hydraulic gradient (i)



Between two points in a hydraulic flow: the difference in total head divided by the length of flow path.
i = Dh / Ds.

hydrostatic pressure

The pressure developed at a depth (z) below the surface of a liquid; it acts equally in all directions.
$u = z \cdot g_w$

hydrostatic thrust (P_w)

The thrust produced on a given surface by body of water.

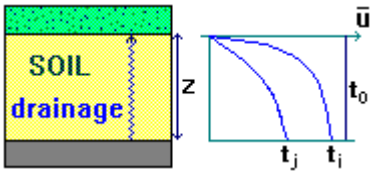
immediate settlement (s_i or r_i)

The settlement of a foundation occurring immediately upon loading.

indurated

Hardened and coherent; the process of induration refers strictly to sedimentary rocks hardened by a combination of pressure (consolidation) and cementation.

isochrone

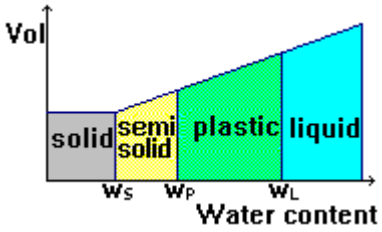


A curve representing the variation in excess pore pressure with depth at a particular time.

isotropic

The same in all directions. e.g. isotropic stress
$s_x = s_y = s_z$

liquid limit (w_L)



The water content above which the soil will flow like a liquid, but below which it will have a plastic consistency; the water content corresponding to a penetration of a standard cone in the BS Liquid Limit Test.

liquidity index (I_L)

$$I_L = \frac{w - w_P}{I_P} = \frac{w - w_P}{w_L - w_P}$$

A measure of the relationship between the current water content of a soil and its consistency limits.
At liquid limit, $I_L = 1.0$
At plastic limit, $I_L = 0$

local side friction (f_s)

The frictional resistance measured along the sleeve in a cone penetration test.

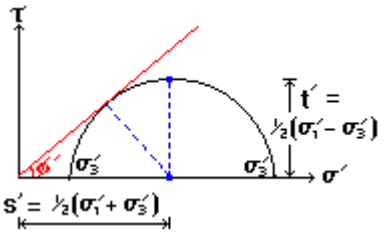
long-term conditions

Conditions in the ground in which any excess pore pressures have dissipated and pore pressures are either hydrostatic or conform to steady-state seepage; long-term conditions are the same as end-of-consolidation and fully-drained.

mass (M, m)

The quantity of matter in a body. Units: grams (g), kilograms (kg), megagrams (Mg).

maximum shear stress in plane strain (t, t')

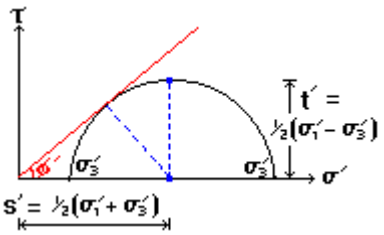


In plane strain the maximum total and effective shear stresses may be written: $t = ½(s_1 - s_3)$ and $t´ = ½(s´_1 - s´_3)$.

mean normal stress (p, p')

The mean value of the three orthogonal stresses:
$p = {}^1/_3(s_1 + s_2 + s_3)$
$p' = {}^1/_3(s'_1 + s'_2 + s'_3)$
$= {}^1/_3(s'_a + 2s'_r)$
$= p - u$

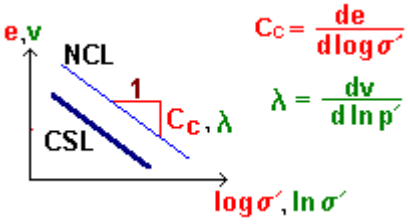
mean stress in plane strain (s, s')



In plane strain the mean stresses may be written
$s' = ½(s'_1 + s'_3)$
$s = ½(s_1 + s_3)$

normal compression line (NCL)

The relationship between void ratio (or specific volume) and (mean) normal effective stress for soil loaded beyond the current yield stress in one-dimensional (or isotropic) compression.



normal force (N, N')

Force acting normal to the plane of reference. Units: kN, N or MN.

normal strain (e_n)

Direct strain acting normal to the plane of reference.

normal stress (s, s')

Stress acting normal to the plane of reference. Units: kPa, kN/m²

normalisation

Analysis of soil test data to compensate for different states of samples.

normalising parameters (p'_c p'_e s'_c s'_e)

(Also equivalent stresses) Parameters used in the normalisation of shear test results: a stress value on either the CSL or NCL having the same specific volume or void ratio value as the current state value.

normally consolidated soil

Soil having a current state which lies on the normal compression line:
· current normal effective stress equals current yield stress
· overconsolidation ratio $R_o = 1$
· generally: "current stress equals maximum stress in the past"

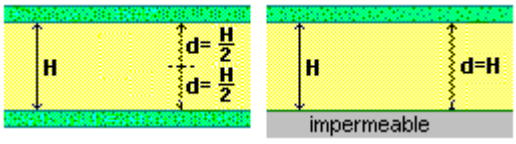
one-dimensional compression

Compression taking place with zero radial and horizontal strain.

one-dimensional modulus (E'_o , M)

The ratio of the change in vertical effective stress to the change in vertical strain, when there is zero horizontal strain.
E'_o (or M) = ds'_a / de_a
$E'_o = 1 / m_v$

open layer



A layer or stratum of soil from which porewater may drain both upward and downward into overlying and underlying permeable layers, thus enabling two-way drainage; drainage path length = half the layer thickness.

optimum water content (w_{opt})

The water content at which the maximum compacted dry density can obtained.

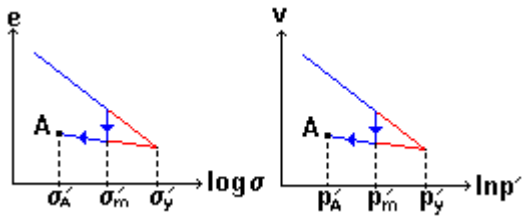
overburden stress (s_{vo}, s'_{vo})

(Also overburden pressure) The stress on a horizontal plane at a given depth due to the weight of overlying soil or rock.

overconsolidated soil

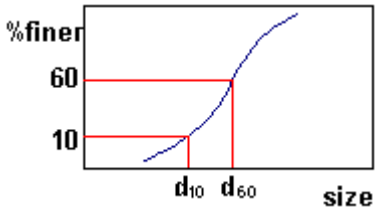
Soil having a current state which lies inside the normal compression line:
· current normal effective stress is less than current yield stress
· overconsolidation ratio $R_o > 1$
· generally: "current stress is less than maximum stress in the past"

overconsolidation ratio (R_m, R_{mp}, R_o, R_p)



The ratio of maximum past effective stress to the current effective stress.
$R_m = s'_m / s'_A$
$R_o = s'_y / s'_A$
$R_{mp} = p'_m / p'_A$
$R_p = p'_y / p'_A$

particle size characteristics (d_n)



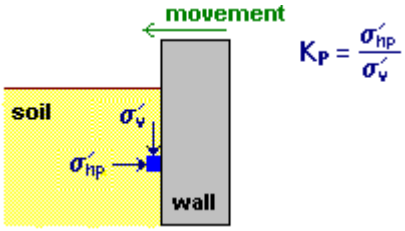
(Also Hazen's characteristics, after Allan Hazen, 1868-1930) Used in particle size analyses and grading: stated as the maximum particle size of a specified percentage (smallest) of the total content of a soil graded by mass.
d_{10} = maximum size of the smallest 10% of the particle content (also referred to as effective size)
d_{60} = maximum size of the smallest 60% of the particle content

pascal (Pa)

(After Blaise Pascal, 1623-62) The derived SI unit of pressure or stress equal to 1 newton per square metre:
1 Pa = 1 N/m²
1 kPa = 1000 Pa

passive earth pressure (s_{hp}, s'_{hp})

The maximum horizontal stress exerted by a mass of soil on a retaining surface as the surface moves toward the soil.



peak shear strength

The maximum shear strength of a soil at a given normal effective stress and water content; this occurs at relatively small strains.

permeability

The property which allows the flow of water through a soil.

See also coefficient of permeability.

pF index

A measure of soil suction: pF = $\log_{10}$ (suction head in cm),
[Range for soils is pF = 0 to 7]

pH value

A measure of acidity or alkalinity of groundwater or soil water extract based on the hydrogen ion content:
pH = -$\log_{10}$(hydrogen ion content)
pH < 7.0 indicates acidity.
pH > 7.0 indicates alkalinity.

piezometer

An instrument used to measure *in situ* pore pressures; may be an open standpipe or an enclosed electronic pressure transducer.

piezometric surface

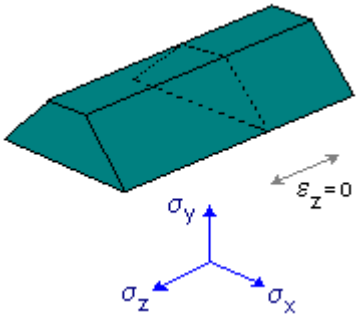
An imaginary surface corresponding to the hydrostatic water level of a confined body of groundwater; the notional level to which artesian pressure would raise water in a (real or imaginary) standpipe.

pile spacing (s)

The distance from centre to centre of piles in a group.

plane strain

A two-dimensional stress state, where the out-of-plane strain (i.e. the strain normal to the plane being considered, e_z) is zero. An example of a plane strain situation would be on a cross-section through a long structure being loaded in the x-y plane, such as an embankment dam.



plastic deformation

The flow or distortion resulting in a permanent and irrecoverable change in shape or volume.

plastic limit (w_p)

(Also PL) The moisture content above which a soil will have a plastic consistency, but below which it crumbles.

plastic strain

Deformation or strain that is not recovered upon unloading.

plasticity

1. The property of a soil (or other material) which allows it to deform continuously.
2. Plasticity theory is used to calculate plastic (irreversible) deformations.

plasticity index (I_p)

(Also PI) The difference between the liquid limit and plastic limit.

$I_p = w_L - w_P$

Poisson's ratio (n, n')
(After Simeon Poisson 1781-1840)
The ratio of the change in strain perpendicular to the direction of loading to the change in strain caused in the same direction.

$n' = - de_y / de_x$ *(for to loading or unloading in the x-direction)*.

For undrained loading of saturated soil,

$n_u = 0.5$

For drained loading or unsaturated soil,

$n' = 0.2 - 0.5$

pore air pressure (u_a)

The pressure of air in a partially saturated soil; not necessarily the same as pore water pressure due to the surface tension on air-water interfaces within the voids.

pore pressure (u)

The pressure exerted by the fluid within the pores or voids in a porous material; in saturated soil the pore pressure is the pore water pressure.

pore pressure coefficient (A)

The ratio of the change in pore pressure to the change in deviator stress, e.g. in an undrained triaxial test; the value of A varies with strain and the overconsolidation ratio.

pore pressure coefficient (B)

The ratio of the change in pore pressure to the change in isotropic stress in undrained loading.

$$B = \frac{\Delta u}{\Delta p}$$

For **saturated** soils, B = 1.

pore pressure force (U)

The resultant force due to pore pressure acting on a given area.

pore pressure ratio (r_u)

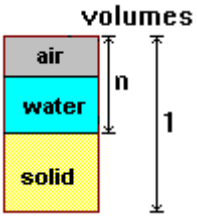
$$r_u = \frac{u}{\sigma_v}$$

At a given point in a body of soil, the ratio of the porewater pressure to the vertical overburden pressure.

pore water pressure (u_w)

(See also pore pressure) In partially saturated soils the pressure exerted by the water in the voids may not be the same as the pore air pressure, due to the surface tension on air-water interfaces.

porosity (n)



The ratio of void volume to total volume:

$n = V_v / V$
where
V_v = volume of voids
V = total volume

potential function (F)

A function introduced in the solution of the Laplace equations defining two-dimensional seepage flow. (See also stream function.)

pressure head (h_w)

(Also head) The height of a column of water required to develop a given pressure u at a given point.
$h_w = u / g_w$

See also total head

pressure in tension crack (p_w)

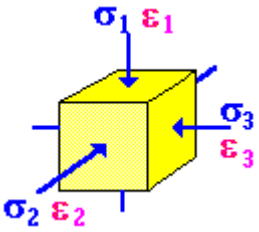
The horizontal pressure exerted in a slope or against a retaining wall due to hydrostatic water pressure in tension cracks.

principal axes

A set of orthogonal axes perpendicular to which the shear stresses and shear strains are zero and normal stresses and strains are referred to as principal stresses and principal strains.

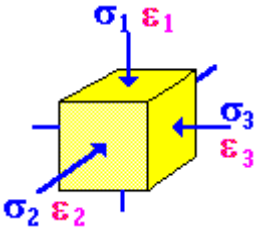
principal strains (e_1, e_2, e_3)

The strains occurring in the directions of the principal axes of strain. Note: the principal axes of stress and strain may not coincide.



principal stresses (s_1, s_2, s_3)

Normal stresses acting in the direction of principal axes of stress. Note: the principal axes of stress and strain may not coincide.



radial stress (s_r , s'_r)

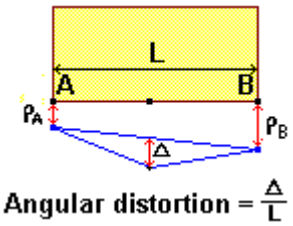
In an axially symmetrical system (e.g. in a triaxial sample), the total or effective stress acting radially, perpendicular to the longitudinal axis.

radius of influence

Theoretically, pumping from a well produces a depression of water pressure or water table which extends to infinite radius. Practically, however, the depression of the water table can be regarded as negligible beyond a certain radius, known as the radius of influence. (For groundwater control purposes, if the required radius of influence is known, and the water table depression is also known, then the flow rate can be calculated as a function of borehole diameter and soil permeability.)

relative deflection (D)

The deflection in a foundation due to settlement, relative to its length or breadth boundaries.



residual shear strength (t_r)

The lowest strength of a clay soil; in the residual state flat particles have become aligned with the slip plane and the flow is laminar;

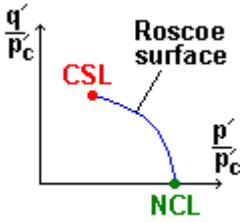
occurs after a large amount of strain has taken place, e.g. as developed along natural landslip surfaces.

resultant thrust

Strictly, the single force that will produce the same effect as several forces acting at a point; also, the force producing the same effect as a pressure or stress distributed over a given area. In earth pressure problems,
P_A = resultant thrust due to active earth pressure

Roscoe surface

Named after Prof. K.H.Roscoe, that part of the state boundary surface between the normal compression line and the critical state line, i.e. on the wet side of critical.



seepage

The flow of water through soil.

seepage force (J)

The force transmitted to a body of soil due to the seepage of groundwater.
$J = i\, g_w\, V$

seepage pressure (j)

The seepage force per unit volume.
$j = i\, g_w$

seepage velocity (v_s)

The average velocity at which groundwater flows through the pores; the ratio of the volume flow rate to the average area of voids in a cross-section.
$v_s = q / A_v$
(See also flow velocity)

sensitivity (S_t)

$$S_t = \frac{\text{undisturbed undrained strength}}{\text{remoulded undrained strength}}$$

A measure of the change in strength of clays upon disturbance: For ordinary clays S_t = 1 to 4, sensitive clays 4 to 8, 'quick' clays 16 - 100.

settlement (s, r)

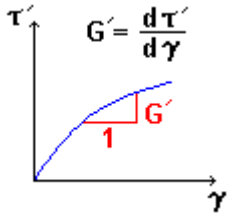
The downward movement of ground or ground surface; the downward movement of a foundation.

shape factors (s_c s_q s_g)

Factors used in a general equation giving ultimate bearing capacity which provide adjustment relating to the shape (e.g. strip, square, circle)

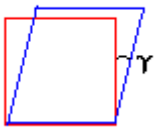
shear modulus (G')

The ratio of the change in shear stress to the resulting change in shear strain.



shear strain (g)

The angular distortion or change in shape of a body of material.



shear strength (t_f)

The maximum shear stress which a material can sustain under a given set of conditions. In soil mechanics it is necessary to refer shear strength to the strain at which the strength is measured.

critical shear strength
$t_c = c'_c + s' \tan f'_c$
peak shear strength
$t_p = c'_p + s' \tan f'_p$
undrained shear strength
$t_c = s_u$
residual shear strength
$t_r = c'_r + s' \tan f'_r$

shear stress (t)

The force per unit area acting tangentially to a given plane or surface. Units: kPa.

short-term conditions

Conditions in the ground when it is undrained; loading or unloading will cause changes in pore pressures, but not immediately in volume; these excess pore pressures dissipate with time due to consolidation.

shrinkage limit (w_s)

(Also SL) The water content below which further reduction in water content causes no further reduction in volume.

skin friction stress (f_s)

The shear stress on the shaft of a pile of a pile or caisson or cone penetrometer.
Note: Although known as 'skin friction', the shear stress may not vary with normal stress.

soil suction

Negative pore pressure created by capillary attraction in fine soils and in unsaturated soils.

specific gravity (G_s)

The ratio of the mass of a body or a substance to the mass of an equal volume of water; the ratio of the density of a body or a substance to that of water.

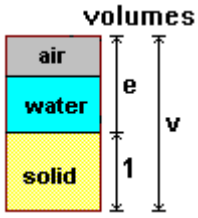
$$G_S = \frac{\text{mass of body}}{\text{mass of the same volume of water}}$$

specific surface (S_s)

The total surface area of all particles in a unit mass of soil. Units: m^2/g.

specific volume (v)

The total volume of a quantity of soil containing a unit volume of soil grains.
v = 1 + e

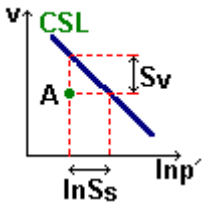


state boundary surface

The state boundary surface (SBS) is the boundary (usually in q':p':v space) to all possible stress-volume states of a soil. If a soil with a state on the state boundary surface is unloaded, the subsequent state will be **inside** the SBS, upon re-loading the subsequent state will move back **onto** (but not beyond) the SBS. In other words, stable states cannot exist outside the SBS.

state parameter (S_s, S_v)

A measure of the distance between the current state (A) and the critical state; expressed as a ratio of stresses or as a difference of specific volumes
$S_s = p'_A / p'_c$
$S_v = v_A - v_c$



steady state pore pressure (u_o)

The pore pressure at equilibrium when all excess pore pressures have fully dissipated.

stiffness

Susceptibility to distortion or volume change under load.

strain

A measure of the change in size or shape of a body, relative to its original size or shape. (Direct strain is the ratio of change in length to original length; shear strain is the angle of distortion; volumetric strain is the ratio of change in volume to original volume.)

stream function (Y)

A function introduced in the solution of the Laplace equations defining two-dimensional seepage flow; the flow-quantity interval (Dq) between stream lines (flow lines) can be stated as DY = Dq.
See also potential function.

stress

The intensity of force per unit area; normal stress is applied perpendicularly to a surface or plane, **shear stress** is applied tangentially to a surface or plane.

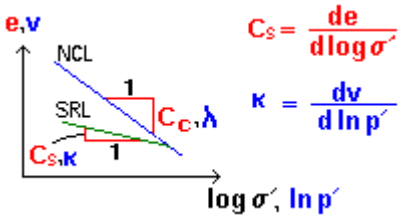
stress history

The past history of loading and unloading associated with a soil.

summation (S)

The symbol S when placed in front of a quantity indicates that the quantity is a sum or total.

swelling / recompression index (C_s, k)



The slope of the swelling (unloading) and recompression (reloading) line.
C_s = 2.303 k
where k = slope of v:ln s´ swelling/recompression line.

tension crack

Cracks appearing at the surface of a soil mass; often occur adjacent to a retaining wall or top of a slope, where they influence the stability analysis.

tension crack depth (z_o)

The depth to which tension cracks extend from the surface and at which the horizontal effective stress is zero.

time factor (T_v)

$$T_v = \frac{c_v t}{d^2}$$

A dimensionless quantity used in consolidation analyses.
c_v = coefficient of consolidation,
t = time,
d = drainage path length

total head (h)

(Also potential) The height of the (notional or real) free water surface above a given datum. Units: m

total head = elevation head + pressure head
$h = h_z + h_w$

total stress (s)

The stress acting on or in a soil mass; due to overlying weight, surcharges, etc.
total stress = effective stress + pore pressure
$s = s' + u$

triaxial shear strain (e_s)

A strain parameter used in the interpretation of triaxial test results.

$$\varepsilon_s = \frac{2}{3}(\varepsilon_a - \varepsilon_r)$$

true cohesion

The strength of soil at zero effective stress. In unbonded soils, true cohesion forces are very small (probably < 3 kPa); for the vast majority of unbonded natural soils true cohesion forces may be ignored; in bonded soils and soft rocks, true cohesion arises from the strength and quantity of material binding the grains together.

ultimate bearing capacity

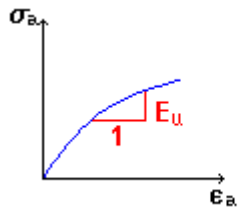
The bearing stress which would cause shear failure in the soil below a foundation; dependent upon the shear strength of the soil and on the shape and depth of the foundation.

undrained loading

Loading which is applied so quickly that there is no time for any drainage of pore water and so there is **no change in volume**; pore pressures may change and lead to subsequent seepage and consolidation.

undrained modulus (E_u)

The ratio of the change in total axial stress and the change in axial strain under undrained loading.



$$E_u = \frac{d\sigma_a}{d\epsilon_a}$$

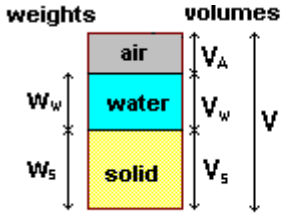
when

$$\delta\sigma_r = 0$$

undrained shear strength (s_u)

(Also undrained strength) The shear strength of a saturated soil at a given water content (or voids ratio, or specific volume) under loading conditions where no drainage of porewater can take place. The undrained shear strength of soil is independent of applied stresses and therefore can be measured at any level of stress, provided the void ratio remains constant. The undrained Mohr-Coulomb envelope will be horizontal ($f_u = 0$).

unit weight (g)



$$\gamma = \frac{W_s + W_w}{V}$$

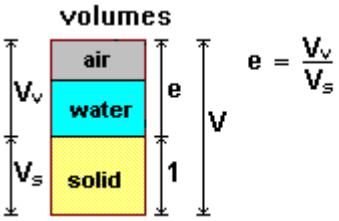
The weight per unit volume of a soil. Units: kN/mł
W_s = weight of solid grains
W_w = weight of water
V = total volume

unit weight of water (g_w)

The weight of a unit volume of water;
g_w = 9.81 kN/mł.

The total or effective stress acting vertically in a soil mass; the subscript z is used when depth is measured along a vertical z-axis.

void ratio (e)



The ratio of the volume of the voids to the volume occupied by the soil grains.
V_w = volume of water
V_s = volume of solid grains.

volume (V)

The amount of space occupied by a body or a quantity of matter.

volume of solids (V_s)

V_s = volume of solid grains in a total soil volume of V.

volume of voids (V_v)

V_v = volume of voids in a total soil volume of V.

volume of water (V_w)

V_w = volume of water in a total soil volume of V.

volumetric strain (e_v)

$$\epsilon_v = \frac{\Delta V}{V_0}$$

$$\epsilon_v = \epsilon_1 + \epsilon_2 + \epsilon_3$$

The ratio of the change in volume to the original volume.

water content (w)

(Also moisture content (m)) The ratio between the mass of water (evaporated at 105°C) and the mass of solid grains in a body of soil.

weight (W)

w = mass of water / mass of solids.
May be obtained by drying a sample of the soil at 105°C to constant weight and then
w = (wet weight - dry weight) / dry weight.

water table

The level in a body of soil at which the hydrostatic water pressure is zero.
(See also piezometric surface)

weight (W)

The force with which a body is attracted towards the centre of the Earth; equal to the mass of the body multiplied by acceleration due to gravity; measured in newtons (N), kilonewtons (kN) or meganewtons (MN); 1 kg at the surface of the Earth is attracted by a gravitational acceleration of 9.81 m/s^2 and exerts a force of 9.81 N (an apple exerts a force of about 1N).

weight of soil grains (W_s)

The weight of soil grains (excluding interstitial and adsorbed water) in a body of soil; equal to the dry weight of a soil.

weight of water (W_w)

The weight of water contained in the voids of a body of soil.

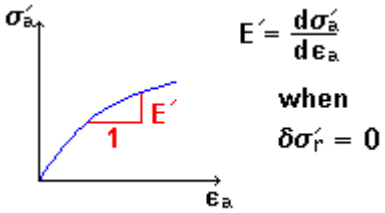
yield point

The point at which material loading behaviour changes from elastic to inelastic.

yield stress (s'_y, p'_y)

The stress at which yielding takes place in soils and other materials; the stress at which the swelling-recompression line joins the normal compression line.

Young's modulus (E_u , E')



(Also, stiffness modulus). The ratio of the change in applied uniaxial stress to the induced direct axial strain, when the lateral (radial) stress remains constant.
E´ is referred to effective stresses
E_u is referred to total stresses (see undrained modulus)